RICH PROTOTYPE FOR THE EIC FORWARD DETECTOR

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on behalf of

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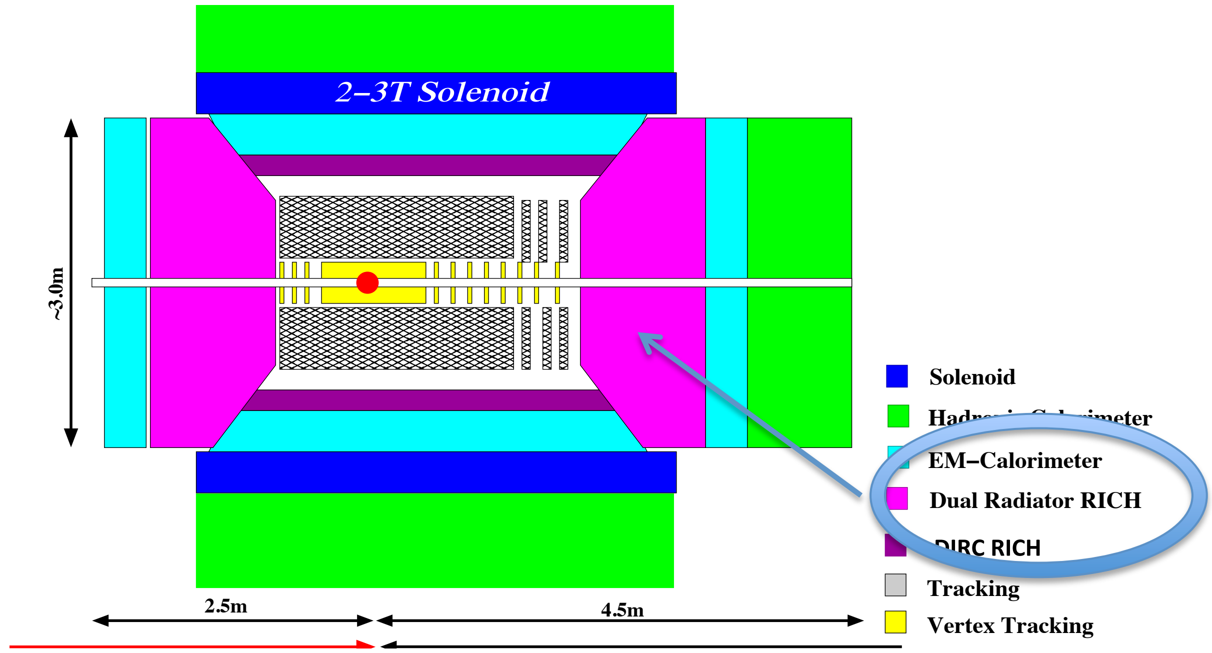
Plan

- Physics motivation
- Prototype overview
  - Aerogel proximity radiator
  - SiPM photodetector
- R&D budget and timeline
- Responsibilities
- Group expertise
- Conclusion

R&D Goal



Build a Ring Imaging Cherenkov Counter (RICH) prototype to be used in the EIC forward region.

Goal of the Project

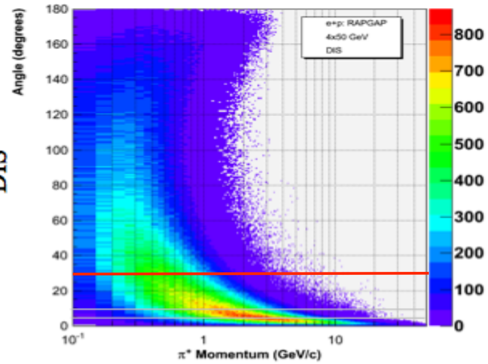
The present project aims to demonstrate the potentiality of a novel type of RICH detector based on proximity focusing aerogel radiator and SiPM photon-detector, which is suitable for the EIC with a potentially broad field of applications.

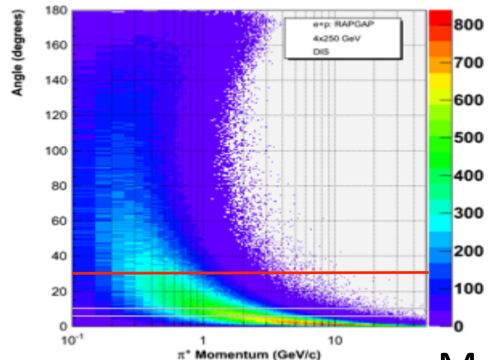
Momentum Distribution

4x50 GeV 4x250 GeV

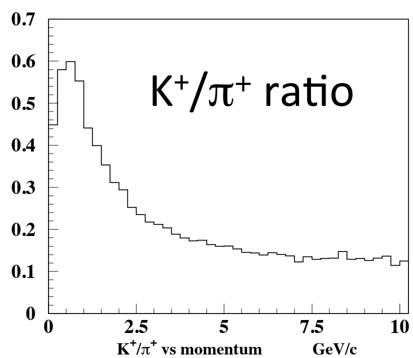
Angle

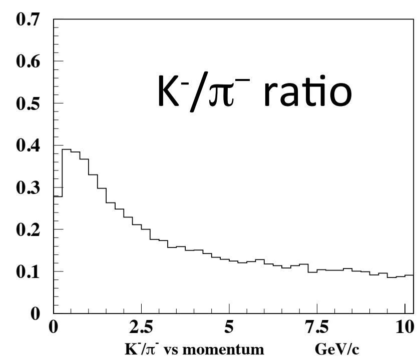
DIS





Momentum

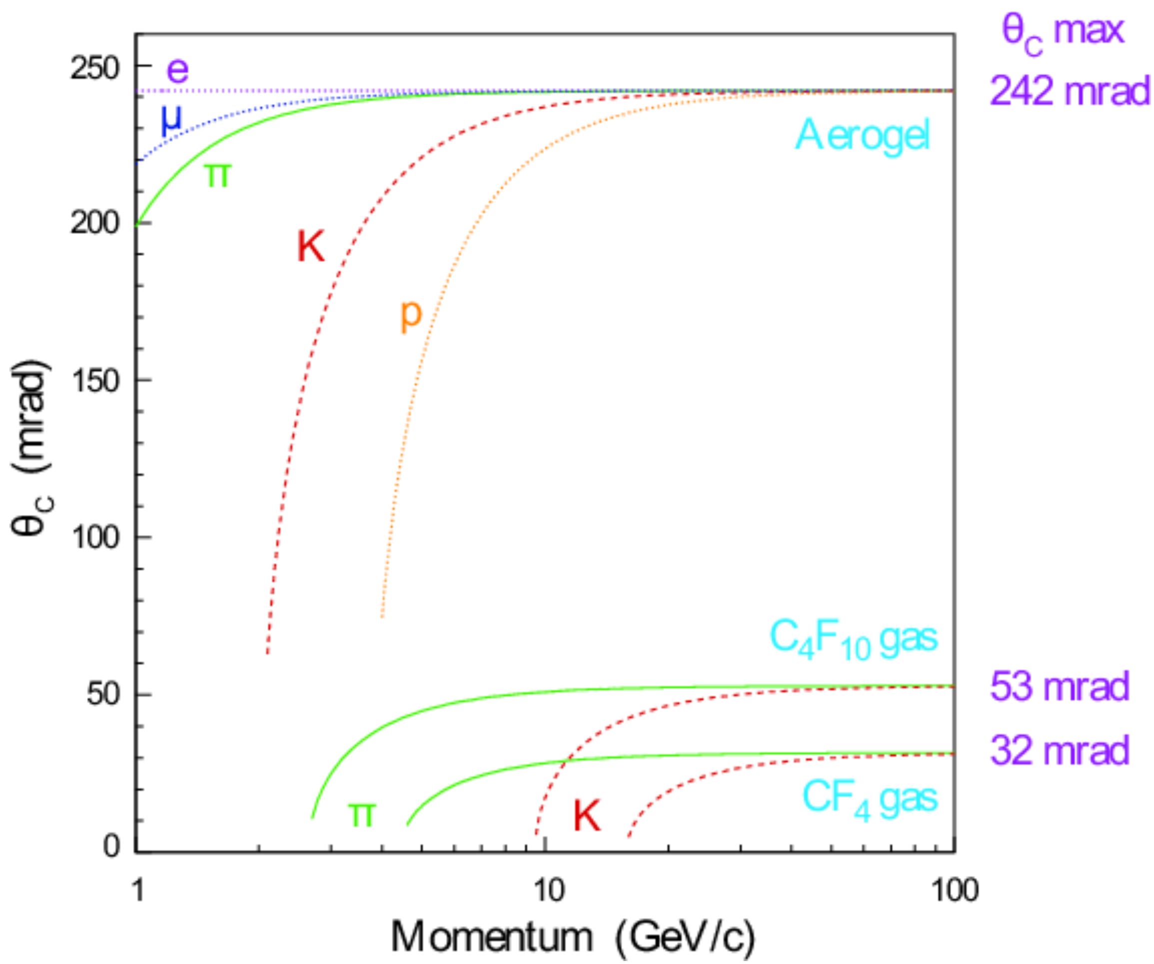




Momentum

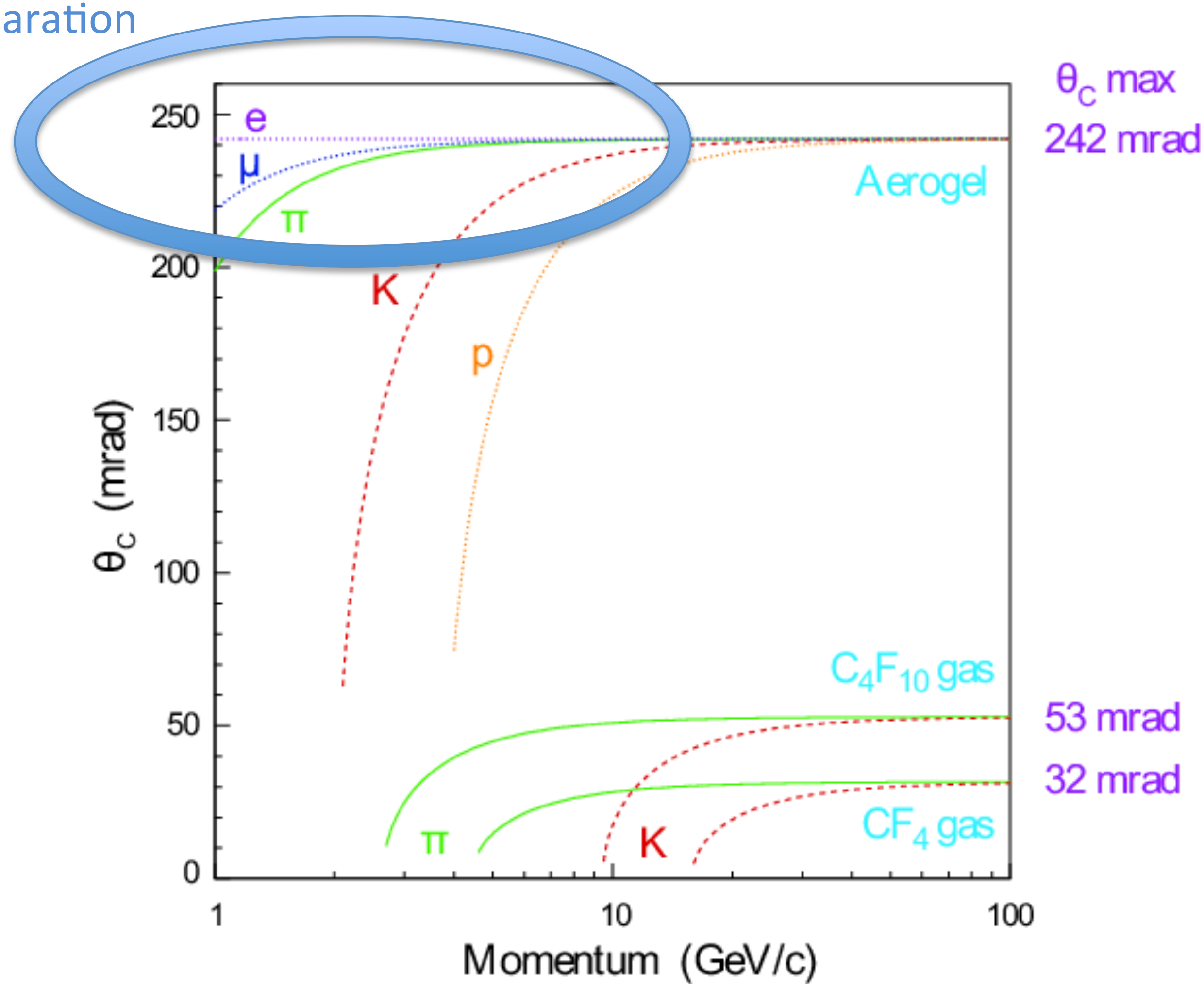
The forward RICH could include a dual radiator: aerogel to discriminate pions from kaons up to the momentum of 10 GeV/c and heavy gas to extend the response to higher momenta.

Cherenkov Angle for the Different Radiators



Cherenkov Angle for the Different Radiators

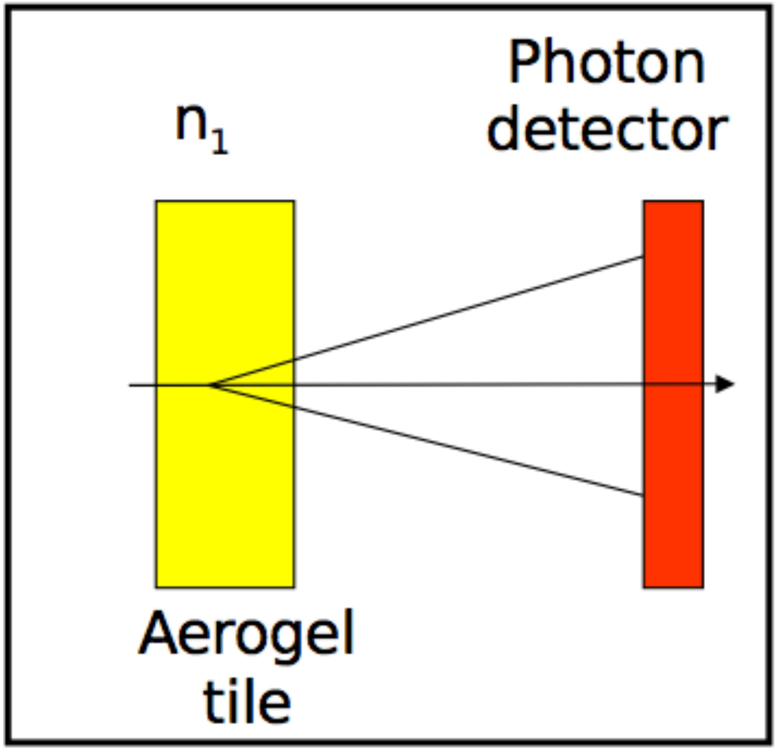
Aerogel RICH
K/π separation

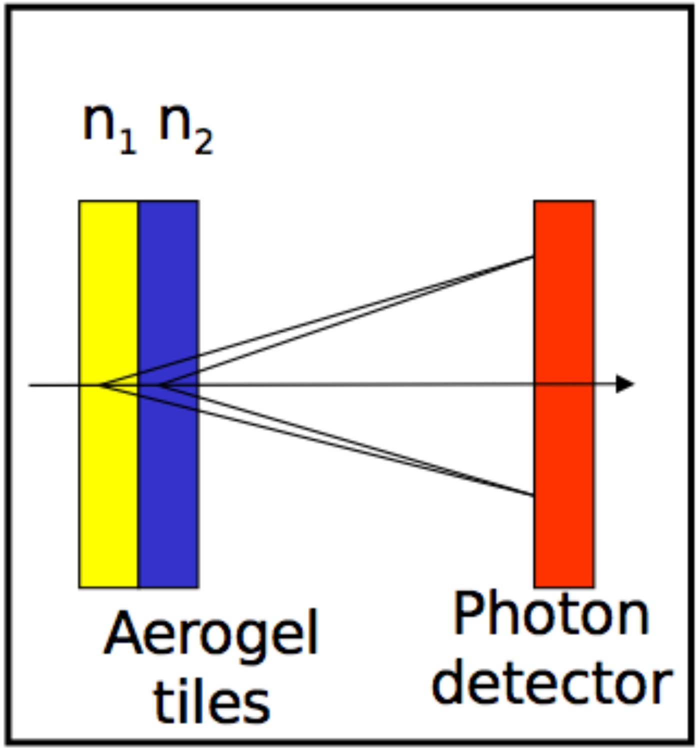


Silica Aerogel

- Refractive index tunable in the range 1.008–1.1 during production to match physical requirements
- Very good optical properties (transmittance and refractive index)
- Excellent refractive index homogeneity
- Large transverse–size tiles available, up to 200×200 mm2

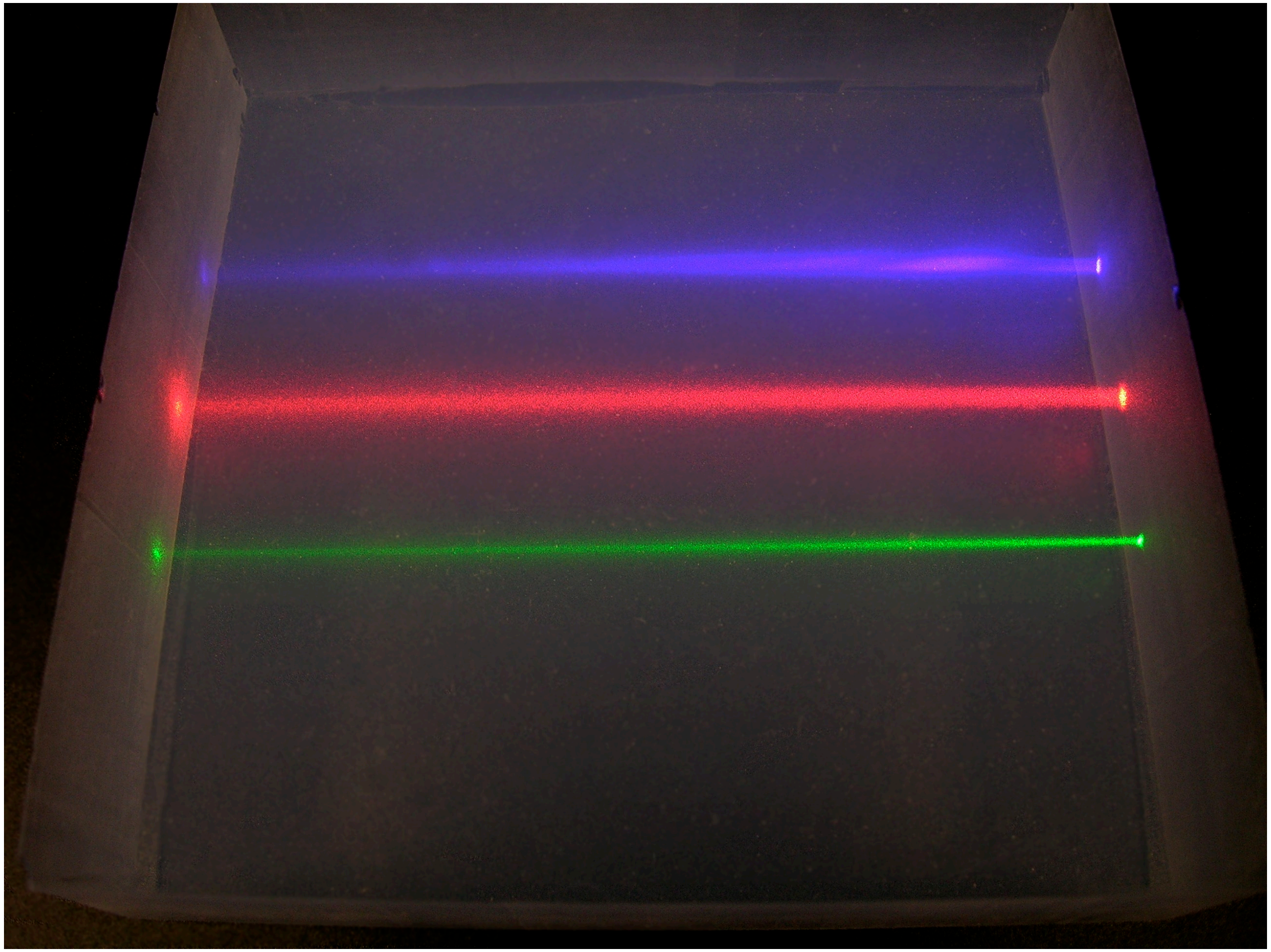
Aerogel proximity RICH





Dual aerogel radiators of the focusing configuration, where two indices are chosen in such a way that emitted Cherenkov photons can form a unified ring image.

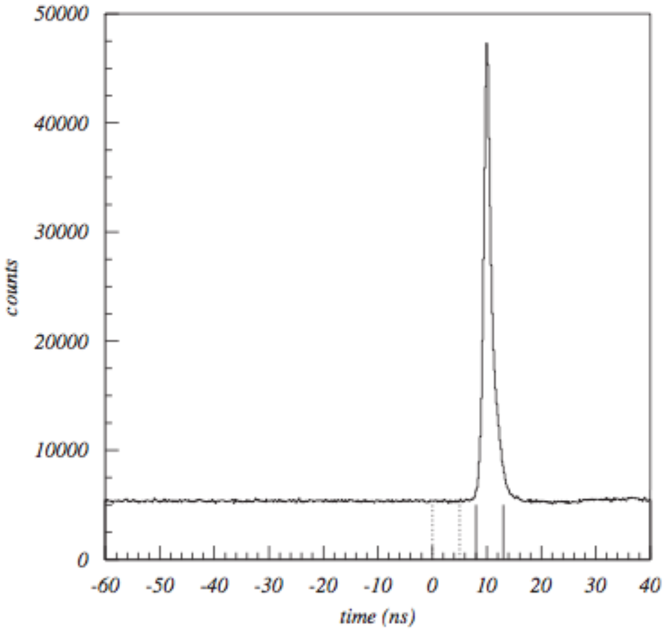
Aerogel Tile

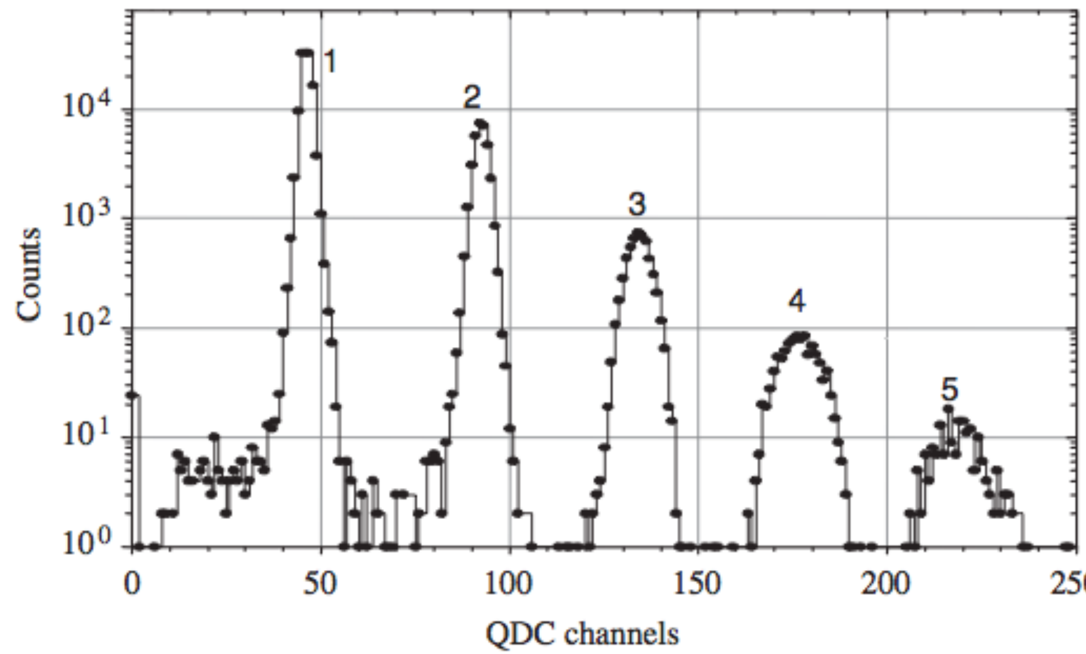


SiPM Photodetector

- The SiPM is a new type of photon device made up of multiple avalanche photodiode pixels operated in Geiger mode
- **High sensitivity to the single photoelectron signal**
- **Insensitivity to magnetic field**
- Room temperature operation
- Low bias (below 100 V) operation
- High gain (up to 10^6)
- Excellent time resolution and space resolution
- High quantum efficiency in a wide range of wavelengths from the visible to the ultraviolet
- Newly developed SiPM arrays (4x4 and 8x8 with 3x3 mm^2)
- Small thickness and limited material budget

SiPM performance

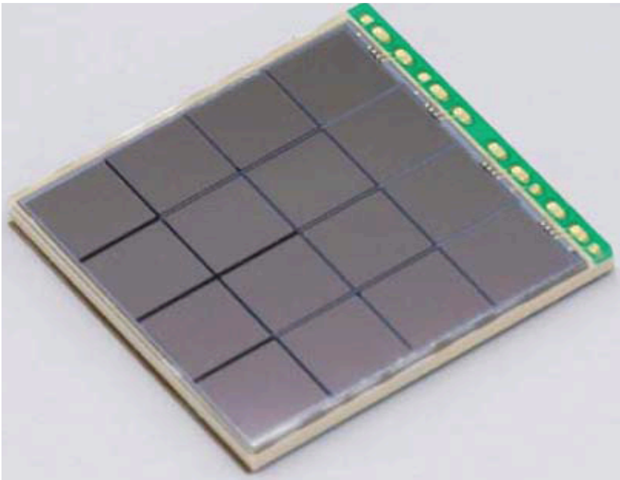




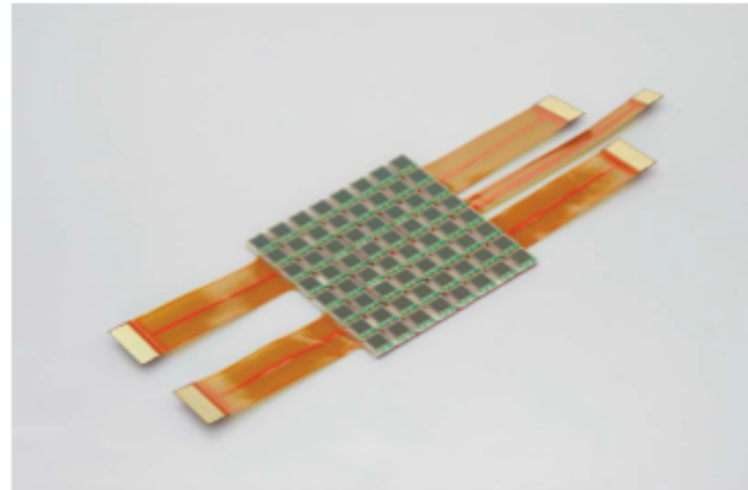
SiPM time spectrum.
Time resolution is around 1 ns
Dolenec et al. NIM A628(2011)

Pulse height distribution
Excellent single photoelectron resolution
Dolgoshein et al. NIM A563(2006)

Monolithic SiPM



SiPM Arrays



	Array	Monolithic
Number of channels	64(8x8)	16(4x4)
Effective area	3x3	3x3 mm
Photon detection efficiency	~50%	~50%
Fill factor	61%	61%
Sencetive area	36%	75-80%

A monolithic SiPM array minimizes the not-active area. It demonstrates the flexibility and compactness of such devices in fast progress.

SiPM as Photodetectors for RICH

- The use of SiPM could have a large impact for RICH detector in the near future, as they are compact and robust devices with a fast decreasing price.
- The intensity of the dark noise is the current main limiting characteristic of these photo-detectors but there is a strong commitment by the producers to reduce it significantly.
- Noticeably, SiPM good timing properties will allow the use of trigger time windows <5 ns, necessary to reduce the high dark noise of these photo-detectors.
- The radiation hardness has to be studied in details. Tests made by the Belle collaboration showed that SiPMs could easily handle neutron flux of about 10^9 n/cm^2 without any deterioration in the characteristics of the signal.

What Will Be Done

- MC simulation of the proposed RICH prototype.
- Studies of the properties of monolithic tiles of aerogel made with layers of different indexes of refraction.
- Studies of the SiPM characteristics such as:
  - photon detection efficiency versus wavelength;
  - pulse height resolution in the region of low number of photoelectrons;
  - time resolution for one-photoelectron signals;
  - dark rate;
  - temperature dependencies of the signal;
  - radiation hardness.
- Design of a power supply card with programmable bias voltage to equalize the SiPM response.
- Design of the fast multichannel front-end electronics, a fast SiPM preamplifier with excellent timing characteristics for one-photoelectron signals.
- Study of the light collector option for the SiPM arrays.
- Cosmic ray test stand that will allow to check the main characteristics of the proposed prototype.
- Test of the prototype with hadron and electron beams in order to verify and improve the performance of the whole detector, including radiator, photo-detector, power supply, preamplifier, front-end electronics and data acquisition.

Management Plan

- We request a total $298K over 3 years

	Year 1	Year 2	Year 3	Total
Postdoc	$45K	$46K	$47K	$138K
Hardware	$38.5K	$61.0K	$14.5K	$114K
Travel	$14K	$15K	$17K	$46K
Total	$97.5K	$122K	$78.5K	$298K

Responsibilities of Institutions

Thomas Jefferson National Accelerator Facility
Christopher Newport University, Newport News, VA

INFN, Laboratori Nazionali di Frascati, Italy
INFN, Sezione di Ferrara, Italy

Universidad Tecnica Federico Santa Maria, Chile

Jlab and CNU

- Simulation and design of the RICH prototype
- Prototype assembling at Jlab
- Light tight box design
- Construction of two trigger detectors
- Data acquisition system
- Development of a dedicated software for the data acquisition and the off-line analyses.
- Test of the SiPM photodetectors.
- Study of light conveyors
- Participation in the prototype tests

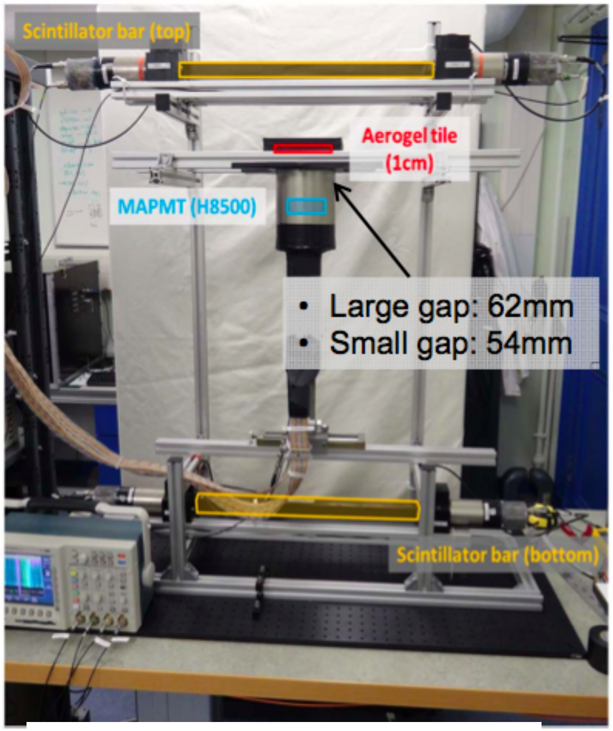
Italian part of the collaboration (INFN)

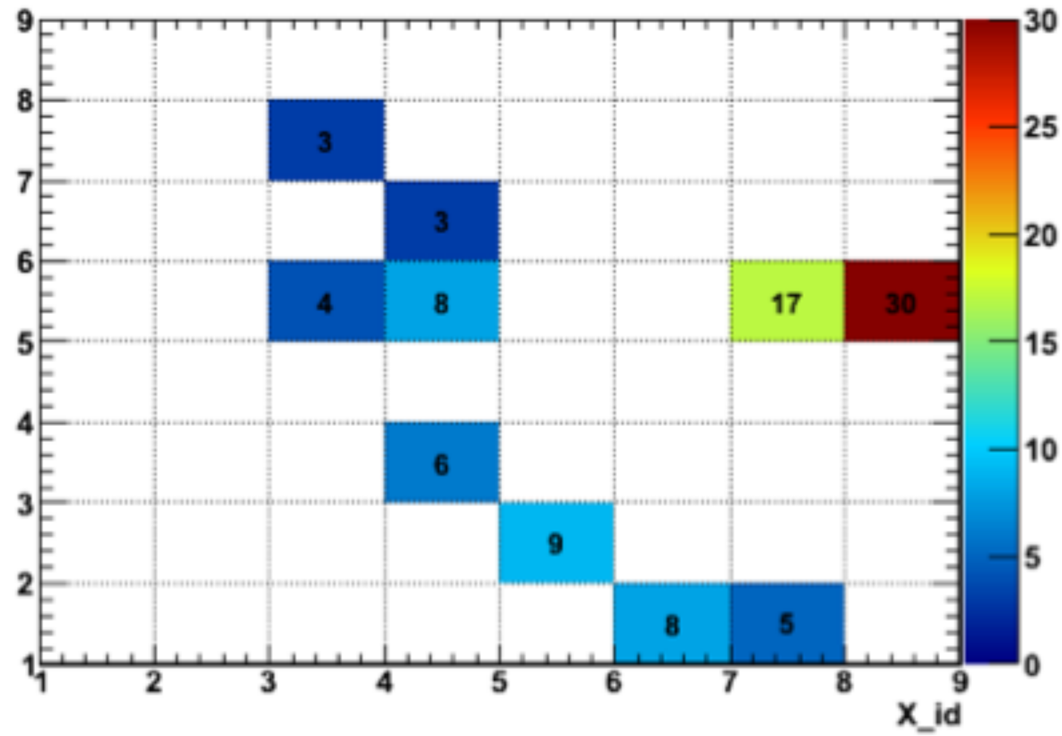
- Acquire mono and multilayer aerogel samples, perform the optical measurements for their characterization in terms of transparency, and measurements of refractive index.
- Study the characteristics of the SiPM photodetectors (quantum efficiency, the linearity and temperature dependence, the noise level)
- Perform the radiation test on different SiPM types using the Co-60 source
- Provide the tracking system based on existing equipment.
- Participation in the prototype tests

Chilean part of the collaboration (UTFSM)

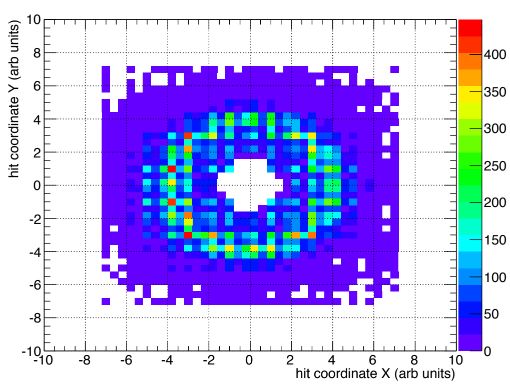
- Development a dedicated front-end readout and power supply system.
- Design and develop a FPGA with software and communication between cards and computer.
- Participation in the prototype tests

Cosmic Stand with Aerogel and Multianode PMT H8500



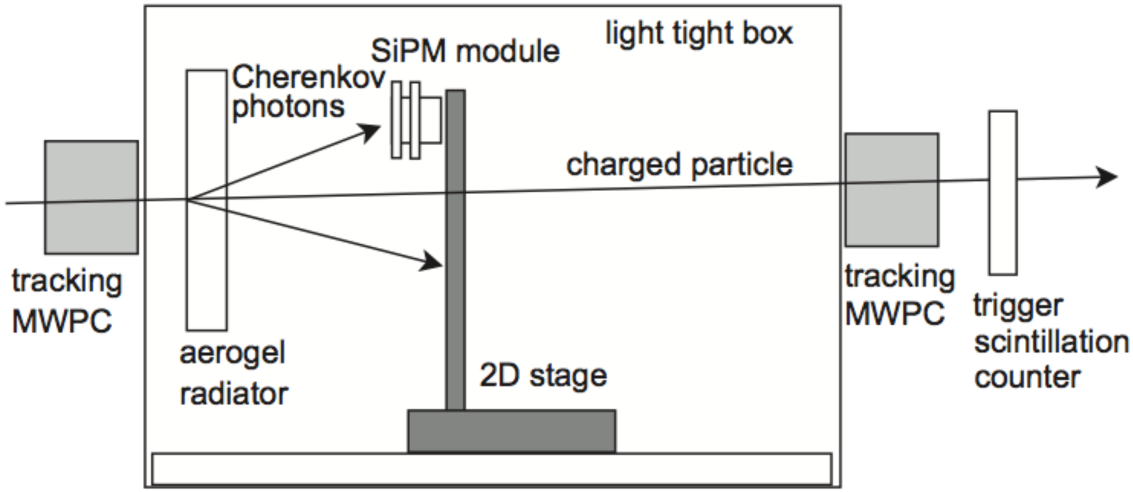


Event display



Integrated over many events x-y distribution

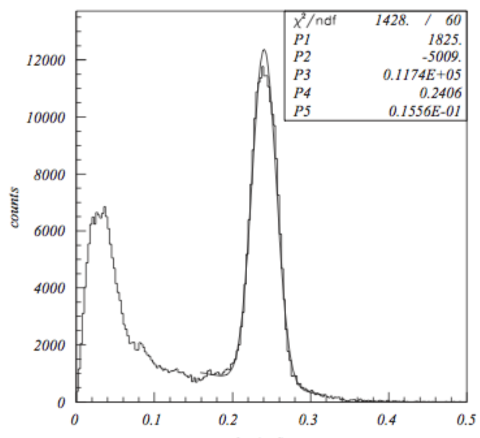
Belle R&D Results



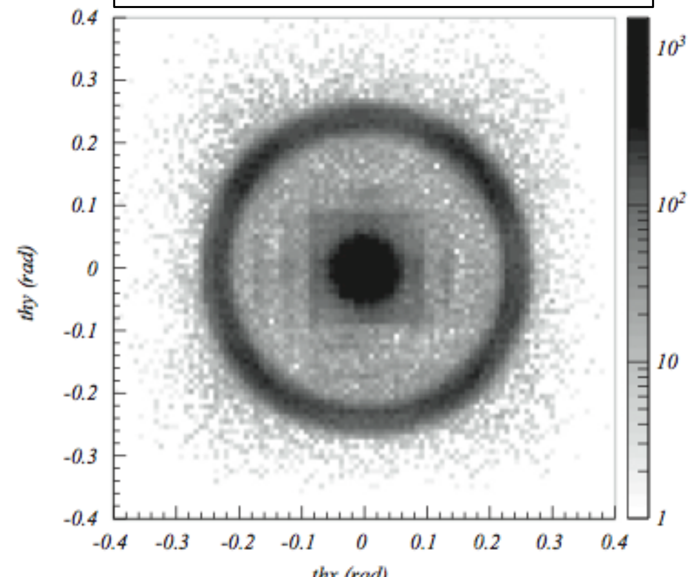
- 1cm aerogel (1.03)
  3.7 photons/ring

Expectations

- 3 cm aerogel (1.05) with 5 cm attenuation length
- Improved light guides
- ***30 photons/ring***

- 

The distributions of hits

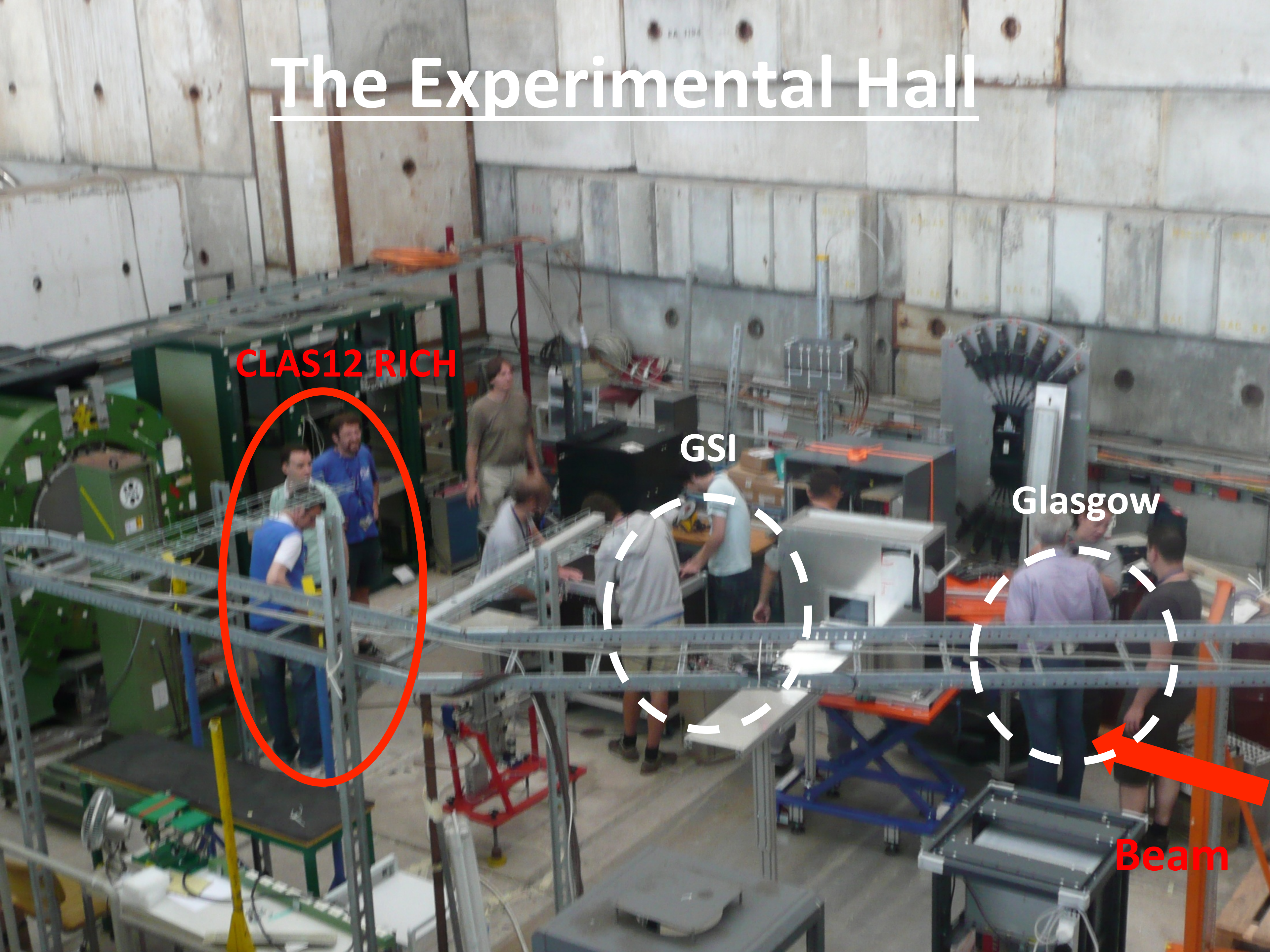


Cherenkov ring (angle space)

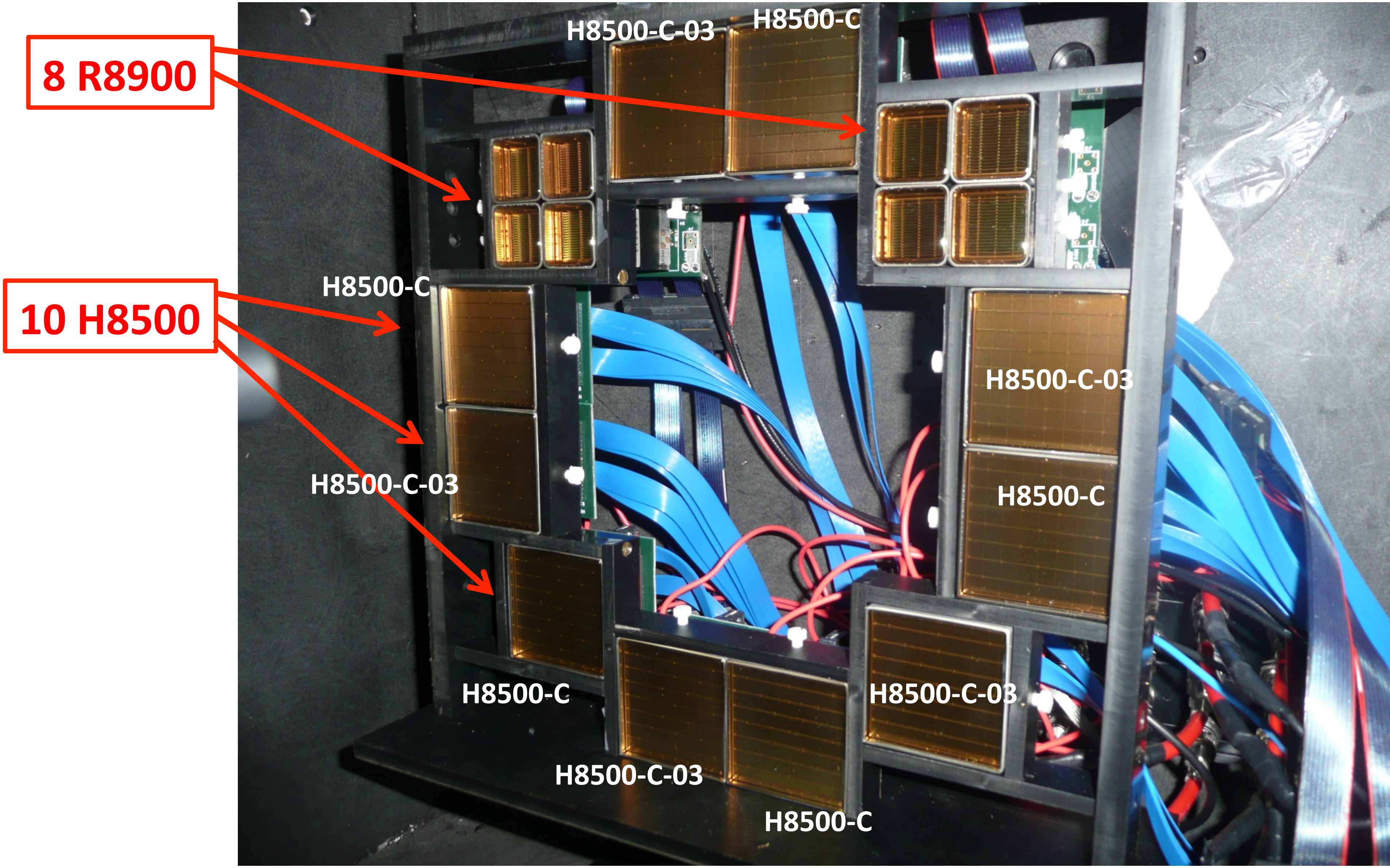
Group Expertise

Test of the CLAS12 RICH detector
at CERN T9 test Beam (July-2011)

The Experimental Hall



The PMT array

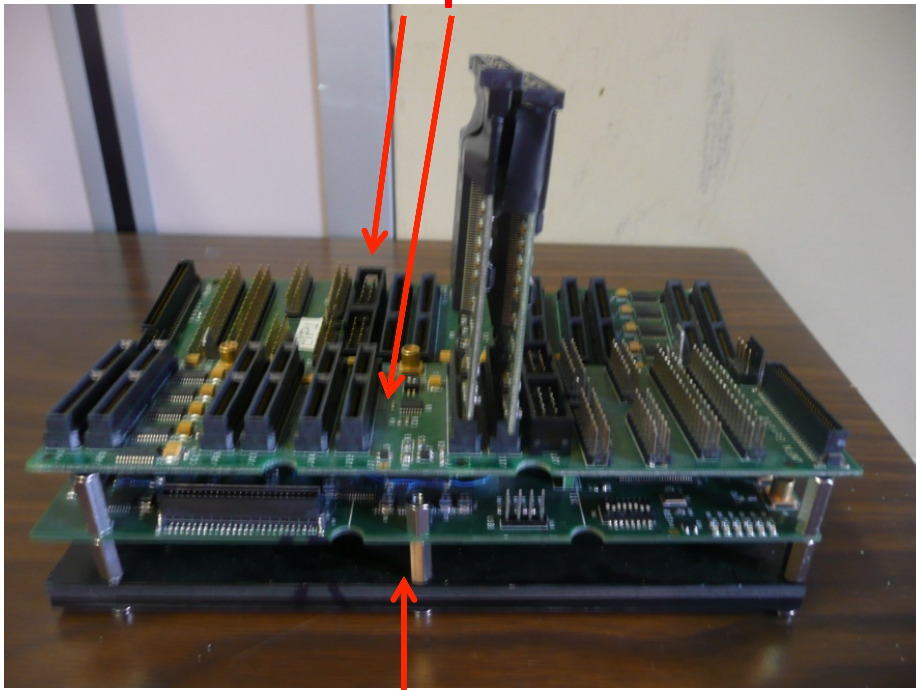


The acquisition electronics

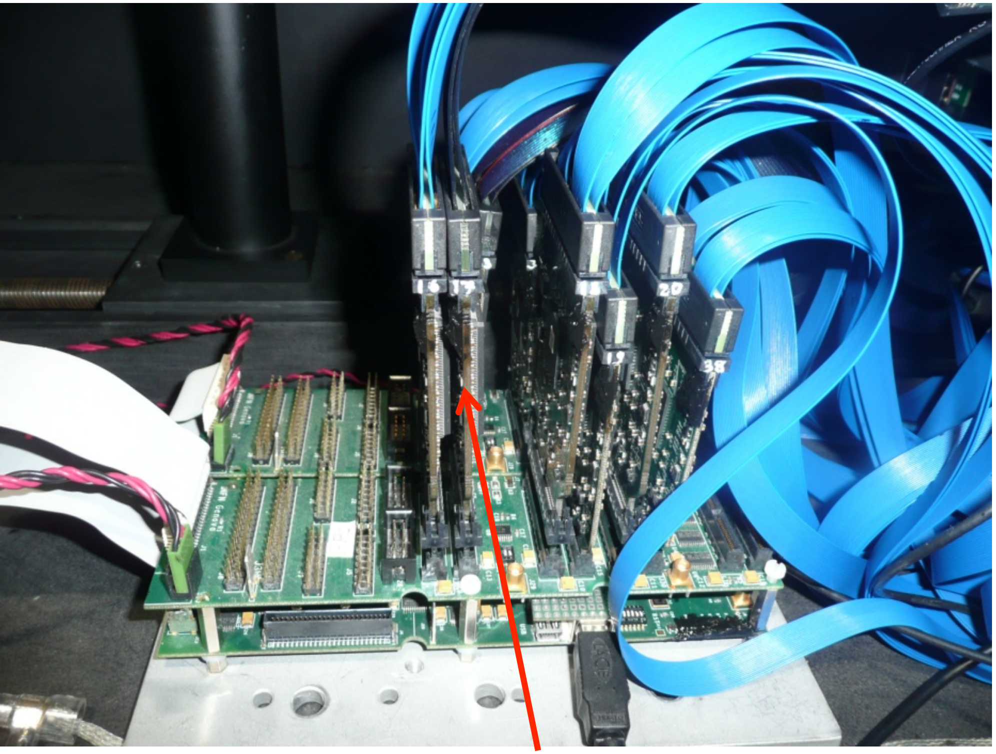
Maroc2 front end electronics

- 1 control board with 2 back planes
- up to 8 front end cards per back plane
- 64 channels per card, 4096 total channels
- preamplifier, adjustable from 1/8 to 4
- ADC, about 80fC per channel

back planes



control board



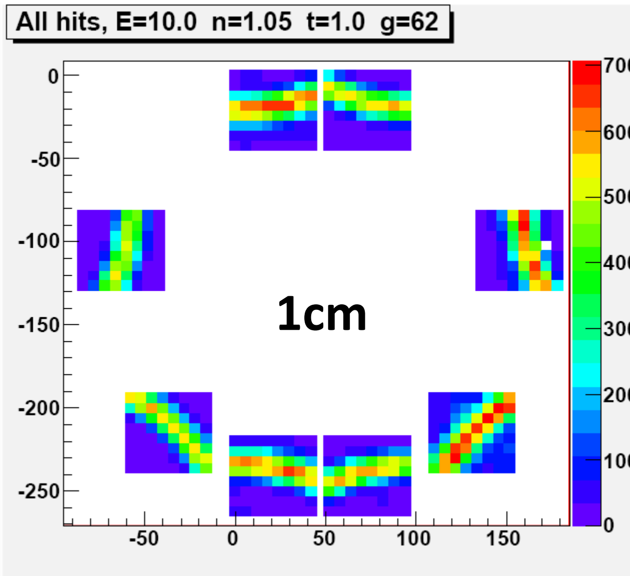
MAROC front end cards

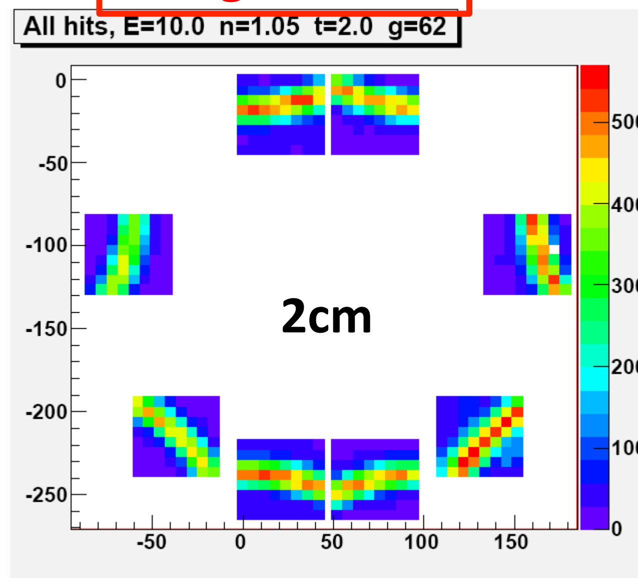
•Visual C++ program to read the electronics (windows)

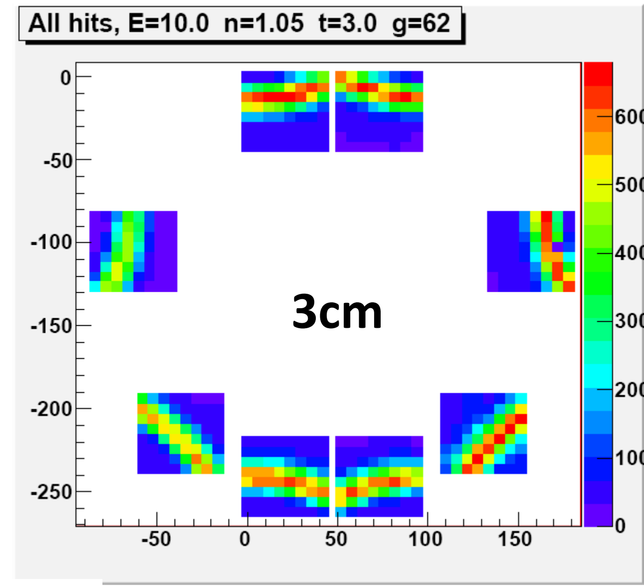
•Event transfer to disk in single or multi event mode

Hit distributions

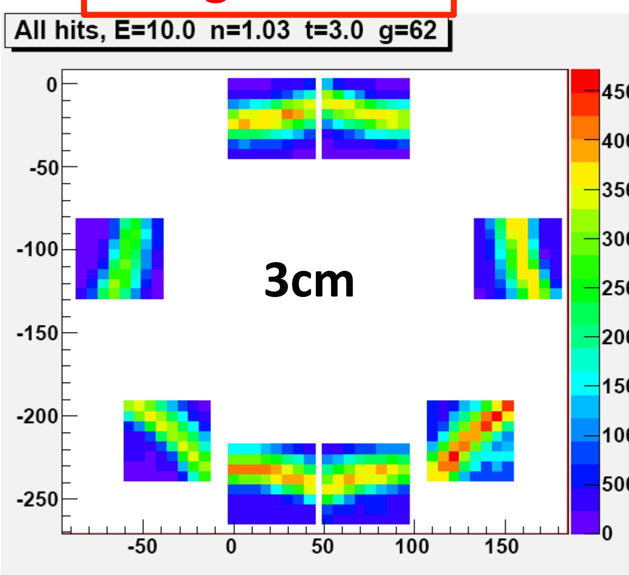
aerogel n=1.05



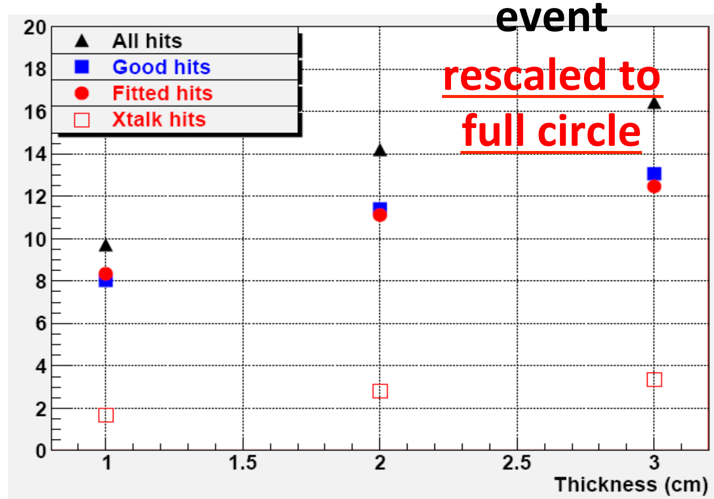




aerogel n=1.03



hits per event



rescaled to full circle

12 phe/ring
as in MC simulaton

Conclusion

- The ultimate goal of this research is to prove the feasibility and the proper functionality of the RICH detector
- The proposed detector exploits the properties of multilayer aerogel radiators and of SiPM photo-detectors
- These are immune to magnetic fields, have a high detection efficiency for photons (single photons in particular), are easy to use, are potentially cheap

END

Thank you for your attention